STARCH GRAINS OF THE WILD AND CULTIVATED MEXICAN SPECIES OF SOLANUM, SUBSECTION POTATOE

Donald Ugent and Michael Verdun
Department of Botany, Southern Illinois University,
Carbondale, IL 62901

This study was undertaken in order to ascertain the usefulness of starch grains in separating the species of the Section Petota of the genus Solanum L. Through microscopic examination of the grains, it was hoped that the identification of fragmentary tuber remains from herbarium specimens and archeological collections might be facilitated, as well as the determination of fresh tubers from potato germ plasm collections.

MATERIALS AND METHODS

Nineteen Mexican species of Solanum, Section Petota were available for study. All were obtained from the Potato Introduction Station, Sturgeon Bay, Wisconsin, where they were grown under uniform environmental conditions.

The tuber grains were examined using phase contrast in both light and dark fields and in conjunction with polarized light (see Verdun, 1982). Two polarizing filters were used, one on either side of the specimen. The amount of polarization was controlled by turning one of the filters until the desired amount of polarization was obtained. Micrographs were made using a Carl Zeiss Standard RA 34 microscope and Eastman Kodak Plus-X film. The prints were made on Kodak Polycontrast II RC paper.

A small piece of each tuber was placed on a microscope slide. The sample was macerated on the slide with a probe handle until it had achieved a watery consistency. Then a drop of water was placed on the slide, followed by the coverslip. Due to the type of lighting used, no stain was required.

Starch grains were examined under medium power (250x). For each preparation, the frequency and shape (Figs. 1 and 2) of the 5 largest starch grains were noted and their size measured with the aid of an ocular micrometer.

RESULTS AND DISCUSSION

In the Mexican species, five distinct starch groups based upon length, an overall width/length ratio, and a hilum length ratio are revealed in the scatter diagram plots (Figs. 3 and 4). These display little or no correlation with previously described series.

Species from South America were also examined using the above mentioned characters and will be reported upon in a later paper. Five distinct groups of Mexican species, based upon the variation in their starch grains, were observed. Solanum tuberosum, the cultivated species, is native to South America but has been included in these Mexican studies for comparative purposes.

The great wealth of morphological variation expressed in the growth form of wild potato species is reflected in the appearance of the starch grains. In the present study, this variation leads to a series of species with similarly sized and shaped starch grains.

Within our groups, further clusters can be observed (Fig. 4). Grain length is the primary basis by which the groups are distinguished from one another, although the width/length ratio is also important in the separation of the grains into subclusters.

In the starch group Bulbocastana, Solanum stoloniferum and S. jamesii form one subcluster, while S. polyadenium, S. brachistotrichum, S. polytrichon, S. bulbocastanum and S. trifidum form another (Fig. 4). Other clustering effects may be observed in the starch group Papita, this encompassing 2 groups. One cluster consists of 3 species, S. demissum, S. papita and S. morelliforme. All have rather similar starch, but these may be distinguished from one another by slight differences in grain length and by the grain width/length ratio. The other two members of this group, S. verrucosum and S. stenophyllidium, while more distantly related from the other 3, all of which have narrower grains, are distinguished from one another primarily by starch grain length.

The remaining starch groups from Mexico, Clara, Pinnatesecta and Guerreroensa, have starch grains of different length. These groupings contain no subclusters within them.

The starch grains of the 19 species examined were predominantly Type A (Fig. 1), but each species presented variations of this class. Thus the starch of each species appears to be unique and readily distinguishable. This enables identification of an unknown plant, even when flowering material is not available.

The utilization of starch grains as a taxonomic feature in the genus Solanum is particularly useful to the archaeologist, as noted by Ugent et. al., 1982. With the aid of the taxonomic keys provided in the present study the worker may place an unknown species of Solanum into a designated starch group. From there it is possible to identify it to species, using the descriptions provided here.

KEY to the MEXICAN STARCH GROUPS*

1. Starch grains less than 48 microns long.....I. Bulbocastana
1. Starch grains greater than 48 microns long.....2
  2. Grains less than 52 microns long.....II. Papita
  2. Grains greater than 52 microns long.....3
    3. Grains less than 62 microns long.....III. Clara
    3. Grains greater than 62 microns long.....4
      4. Grains less than 66 microns long.....
      .....IV. Pinnatisceta
      4. Grains greater than 66 microns long.....
      .....V. Guerreroensa

STARCH GROUP I BULBOCASTANA.

Grains ovoid or shell shaped, 32 to 52 microns long, averaging 40 microns; 16 to 36 microns wide, with a mean of 24 microns; hilum 4 to 12 microns from proximal end, averaging 8 microns. Eightyseven percent consists of Type A (Figs. 1 and 2), with the remainder being types B, D, F, G, H, I, J, or K.

1. SOLANUM STOLONIFERUM Schlechtd. et Bche. (Figs. 5, 6).
Grains ovoid; 32 to 44 microns in length, averaging 37 microns; varying 16 to 35 microns in width, with a mean of 21 microns; hilum located 4 to 8 microns from proximal end of grain, with a mean of 7.8 microns. Eightyfive percent consists of Type A (Figs. 1 and 2), with the remainder being types D, F, or I.

2. SOLANUM JAMESII Torr. (Figs. 7, 8).
Grains globose; 36 to 40 microns in length, averaging 38 microns; varying 20 to 35 microns in width, with a mean of 23 microns; hilum located 8 microns from proximal end of grain. Ninety percent consists of Type A (Figs. 1 and 2), with the remainder being Types D, F, or J.

3. SOLANUM TRIFIDUM Schlechtd. (Figs. 9, 10).
Grains ellipsoid; 36 to 44 microns in length, averaging 40 microns; varying 24 to 32 microns in width, with a mean of 26 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 9 microns. Ninetyfive percent consists of Type A (Fig. 1), with the remainder being Type D.

4. SOLANUM POLYADENIUM Greenm, (Figs. 11, 12).
Grains narrowly to broadly ovoid; 36 to 44 microns in length, averaging 40 microns; varying 16 to 24 microns in width, with a mean of 20 microns; hilum located 4 to 8 microns from proximal end of grain, with a mean of 6 microns. All consist of Type A (Fig. 1).

5. SOLANUM BRACHISTOTRICHUM (Bitt.) Rydb, (Figs. 13, 14).
Grains ovoid; 32 to 52 microns in length, averaging 40 microns; varying 16 to 28 microns in width, with a mean of 20 microns; hilum located 4 to 12 microns from proximal end of grain, with a mean of 7 microns. Eightythree percent consists of Type A (Figs. 1 and 2),

*Based on an average of the five largest starch grains per preparation.

with the remainder being Types D, F, G, or I.

6. SOLANUM BULBOCASTANUM Dun. (Figs. 15, 16).

Grains ellipsoid-ovoid; 36 to 48 microns in length, averaging 40 microns; varying 20 to 28 microns in width, with a mean of 25 microns; hilum located 4 to 12 microns from proximal end of grain, with a mean of 8 microns. Eightysix percent consists of Type A (Figs. 1 and 2), with the remainder being Types G, H, or K.

7. SOLANUM POLYTRICHON Rydb, (Figs. 17, 18).

Grains shell-like to ellipsoid, varying to ovoid, or with sharp angular sides; 40 to 44 microns in length, averaging 42 microns; varying 20 to 24 microns in width, with a mean of 23 microns; hilum located 4 to 8 microns from proximal end of grain, with a mean of 6 microns. Seventythree percent consists of Type A (Figs. 1 and 2), with the remainder being Types B, F, or G.

8. SOLANUM CARDIOPHYLLUM Lindl. (Figs. 19, 20).

Grains ovoid to globose; 36 to 48 microns in length, averaging 42 microns; varying 16 to 36 microns in width, with a mean of 28 microns; hilum located 8 microns from proximal end of grain. Ninety percent consists of Type A (Figs. 1 and 2), with the remainder being Type F or G.

9. SOLANUM FENDLERI A. Gray (Figs. 21, 22).

Grains ellipsoid-ovoid; 40 to 52 microns in length, averaging 44 microns; varying 28 to 36 microns in width, with a mean of 32 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 10 microns. Ninetyone percent consists of Type A (Figs. 1 and 2), with the remainder being Type F or K.

STARCH GROUP II PAPITA.

Grains ellipsoid to ovoid; 36 to 60 microns long, averaging 51 microns; 12 to 36 microns wide, with a mean of 26 microns; hilum 4 to 20 microns from proximal end averaging 9 microns. Ninetytwo percent consists of Type A (Figs. 1 and 2), with the remainder being Types C, D, F, or G.

10. SOLANUM DEMISSUM Lindl. (Figs. 23, 24).

Grains very narrowly ellipsoid, 44 to 60 microns in length, averaging 50 microns; varying 16 to 32 microns in width, with a mean of 22 microns; hilum located 8 microns from proximal end of grain. Ninetysix percent consists of Type A (Figs. 1 and 2), with the remainder being Type D or G.

11. SOLANUM PAPITA Rydb. (Figs. 25, 26).

Grains ellipsoid-ovoid, or irregular; 44 to 60 microns in length, averaging 50 microns; varying 16 to 32 microns in width, with a mean of 23 microns; hilum located 4 to 8 microns from proximal end of grain, with a mean of 7 microns. Ninety percent consists of Type A (Figs. 1 and 2), with the remainder being Type F or G.

12. SOLANUM MORELLIFORME Bitt. et Muench (Figs. 27, 28).

Grains very narrowly ellipsoid, tending to be irregular or angular; 36 to 50 microns in length, averaging 51 microns; varying 12 to 36 microns in width, with a mean of 24 microns; hilum located 4 to 12 microns from proximal end of grain, with a mean of 7 microns.

Ninety percent consists of Type A (Figs. 1 and 2), with the remainder being Types C, D, F, or G.

13. SOLANUM VERRUCOSUM Schlechtd. (Figs. 29, 30).

Grains ovoid, or slightly irregular; 48 to 52 microns in length, averaging 50 microns; varying 28 to 32 microns in width, with a mean of 29 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 11 microns. Eightynine percent consists of Type A (Figs. 1 and 2), with the remainder being Types C, F, or G.

14. SOLANUM STENOPHYLLIDUM Bitt. (Figs. 31, 32).

Grains ovoid; 48 to 52 microns in length, averaging 52 microns; varying 24 to 36 microns in width, with a mean of 31 microns; hilum located 8 to 20 microns from proximal end of grain, with a mean of 14 microns. Eightynine percent consists of Type A (Figs. 1 and 2), with the remainder being Types F, D, or G.

STARCH GROUP III CLARA.

Grains ovoid to ellipsoid; 42 to 68 microns long, averaging 59 microns; 28 to 44 microns wide, with a mean of 36 microns; hilum 8 to 12 microns from proximal end, averaging 10 microns. Seventyfour percent consists of Type A (Figs. 1 and 2), with the remainder being Types F, G, K, or H.

15. SOLANUM CLARUM Corr. (Figs. 33, 34).

Grains narrowly ovoid; 42 to 64 microns in length, averaging 58 microns; varying 28 to 40 microns in width, with a mean of 34 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 10 microns. Ninetythree percent consists of Type A (Figs. 1 and 2), with the remainder being Type F or G.

16. SOLANUM BRACHYCARPUM Corr. (Figs. 35, 36).

Grains irregularly ovoid to globose; 48 to 68 microns in length, averaging 60 microns; varying 32 to 44 microns in width, with a mean of 39 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 10 microns. Eightythree percent consists of Type A (Figs. 1 and 2), with the remainder being Types F, G, H, or K.

STARCH GROUP IV PINNATISCETA.

Grains ovoid; 48 to 76 microns long, averaging 64 microns; 32 to 40 microns wide, with a mean of 34 microns; hilum 8 to 12 microns from proximal end of grain, with a mean of 10 microns. Eighty two percent consist of Type A (Figs. 1 and 2), with the remainder being Types B, D, F, G, H, or I.

17. SOLANUM TUBEROSUM L. (Figs. 37, 38).

Grains broadly ovoid; 48 to 76 microns in length, averaging 64 microns; varying 32 to 36 microns in width, with a mean of 33 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 10 microns. Eightytwo percent consists of Type A (Figs. 1 and 2), with the remainder being Types D, F, or G.

18. SOLANUM PINNATISECTUM Dun. (Figs. 39, 40).
Grains very large, ellipsoid; 60 to 72 microns in length, averaging 65 microns; varying 32 to 40 microns in width, with a mean of 36 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 10 microns. Eightyfour percent consists of Type A (Figs. 1 and 2), with the remainder being Types B, D, F, G, H, or I.

STARCH GROUP V GUERREROENSA.

Grains companulate; 56 to 76 microns long, averaging 69 microns; 28 to 68 microns wide, with a mean of 51 microns; hilum 8 to 12 microns from proximal end, averaging 11 microns. Eightyeight percent consists of Type A (Figs. 1 and 2), with the remainder being Type F.

19. SOLANUM GUERREROENSE Corr. (Figs. 41, 42).
Grains narrowly irregular to broadly campanulate; 56 to 76 microns in length, averaging 69 microns varying 28 to 68 microns in width, with a mean of 51 microns; hilum located 8 to 12 microns from proximal end of grain, with a mean of 11 microns. Eightyeight percent consists of Type A (Figs. 1 and 2), with the remainder being Type F.

ACKNOWLEDGEMENT

Thanks are due to Mr. Roman Ross of the Potato Introduction Station, Sturgeon Bay, Wisconsin, for sending us the tuber materials used in this study.

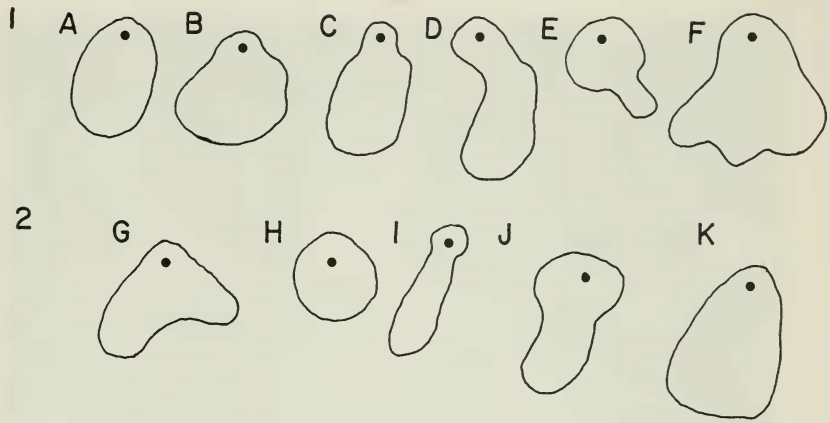
LITERATURE CITED

Correll, D.S. 1962. The Potato and It's Wild Relatives. Texas Research Foundation, Renner, Texas. 606 pp.

Hawkes, J.G. 1963. A Revision of the Tuber-Bearing Solanums. Rec. Scott. Pl. Breed. Stn. 76-181.

Ugent, D., S. Pozorski and T. Pozorski. 1982. Archaeological potato tuber remains from the Casma Valley of Peru. Economic Botany, 36:182-192.

Verdun, M.P. 1982. Starch Grains: A Taxonomic Character in Solanum (Tourn) L. Section Tuberarium. Unpublished Masters Thesis. Southern Illinois University, Carbondale. 47 pp.



Figs. 1 and 2. Variation in Solanum starch grains.

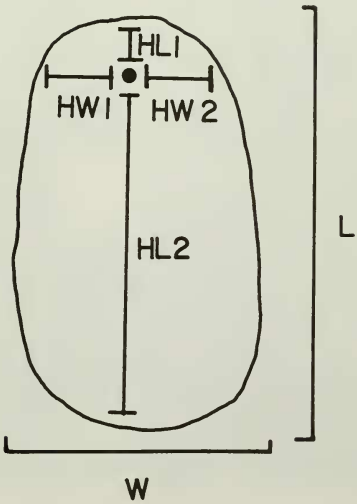


Fig. 3. Starch grain measurements taken in this study; width (W); length (L); length from the hilum to the proximal edge (HL_1); length from the hilum to the farthest edge (HL_2); length from the hilum to the closest lateral edge (HW_1); and the length from the hilum to the farthest lateral edge (HW_2).

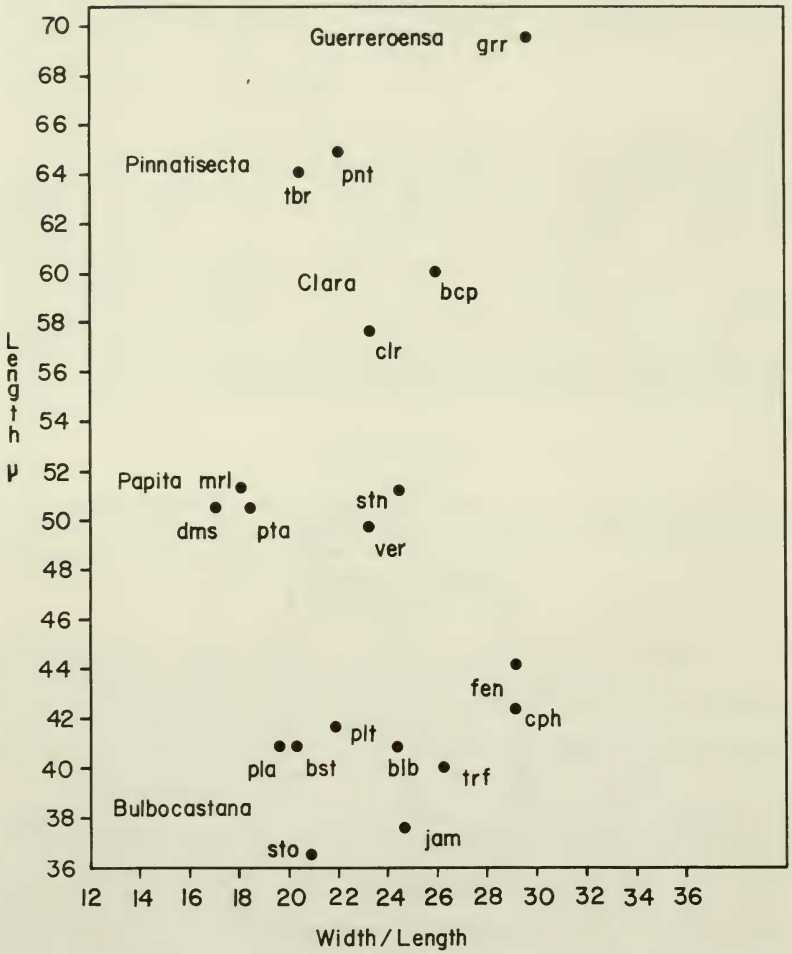
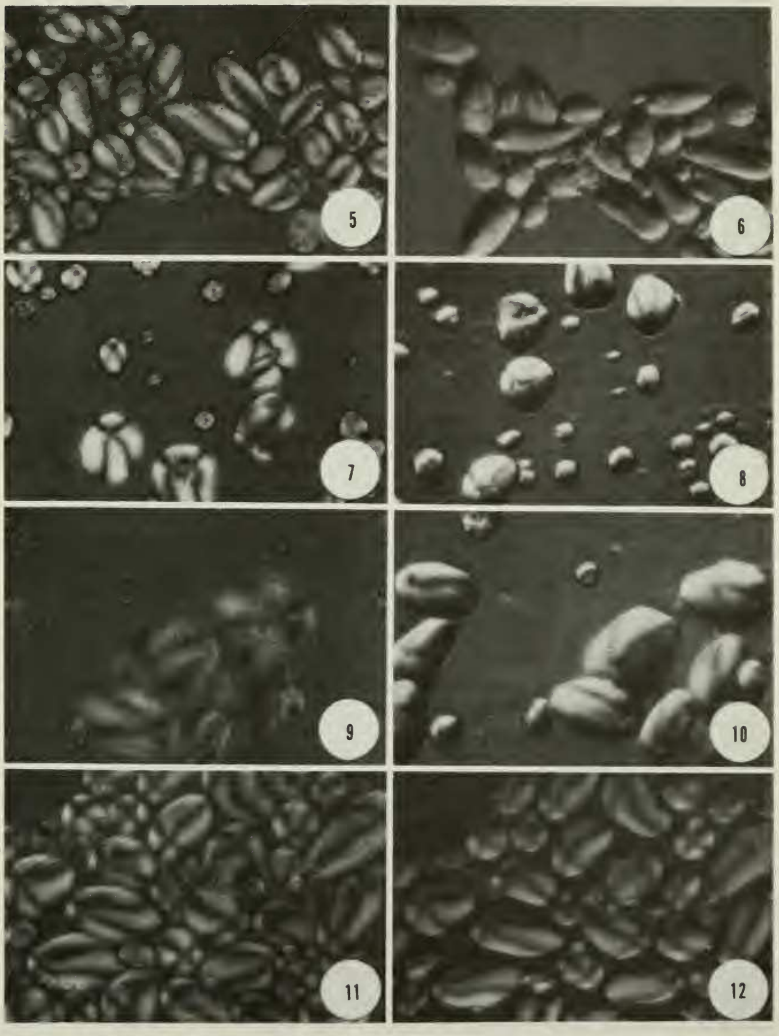
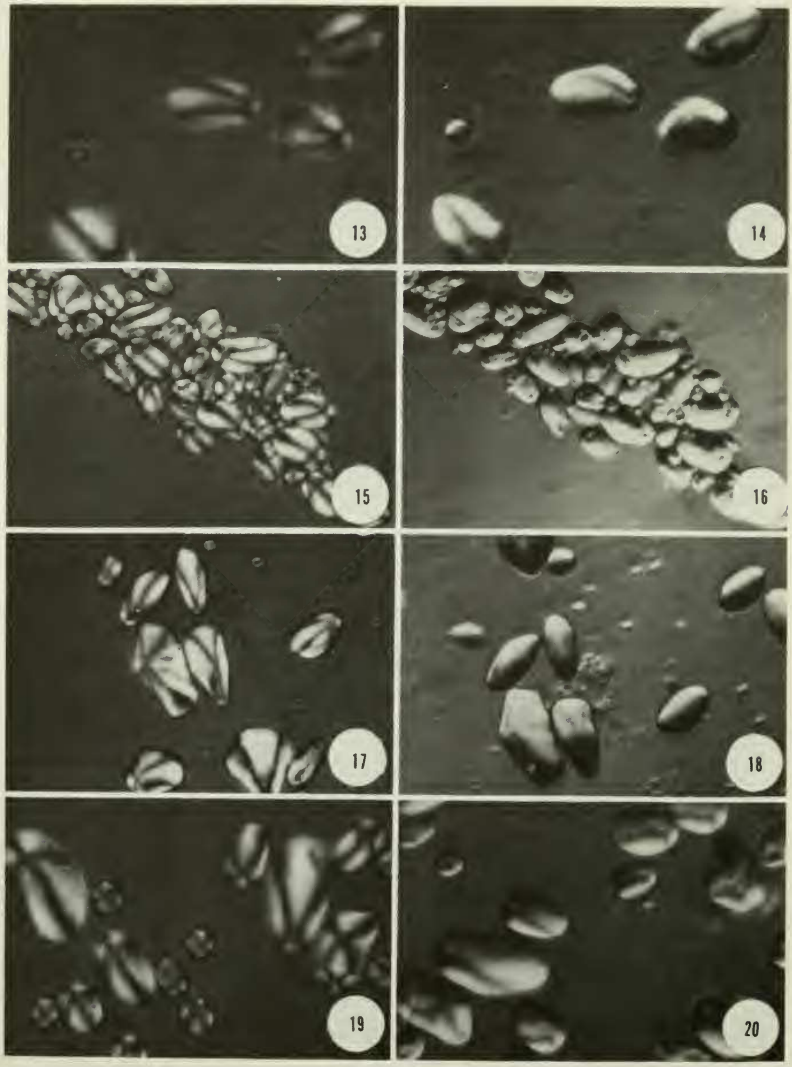


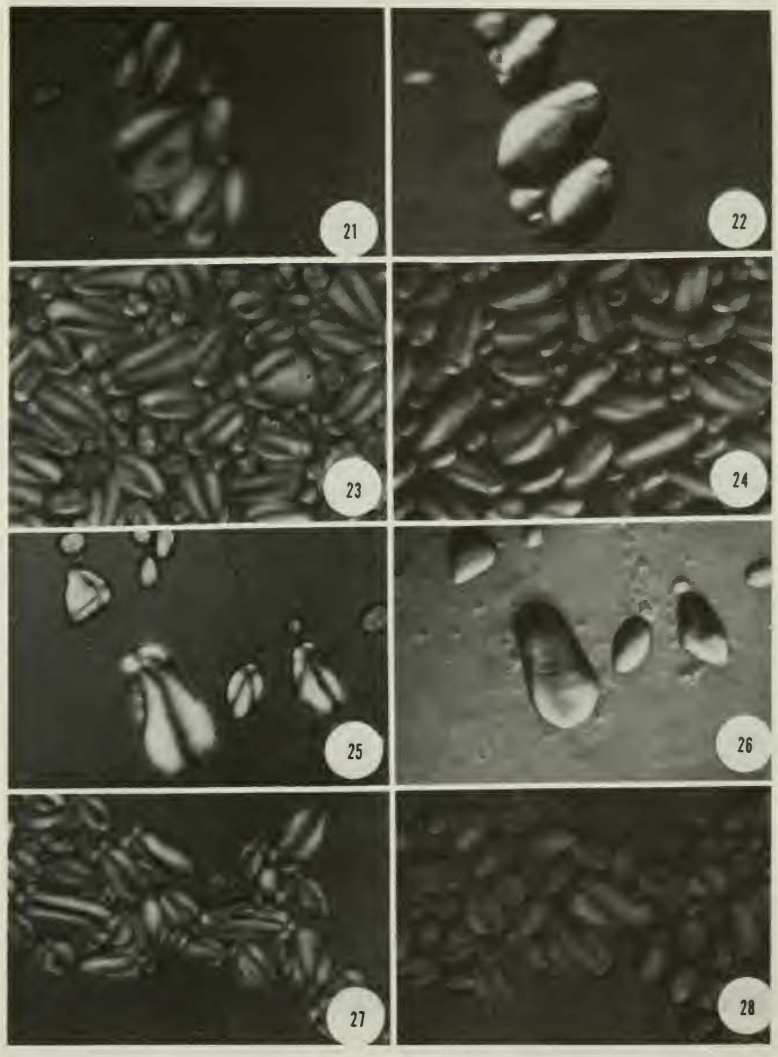
Fig. 4. Starch types in Solanum, Sect. Petota, Subsection Potatoe.



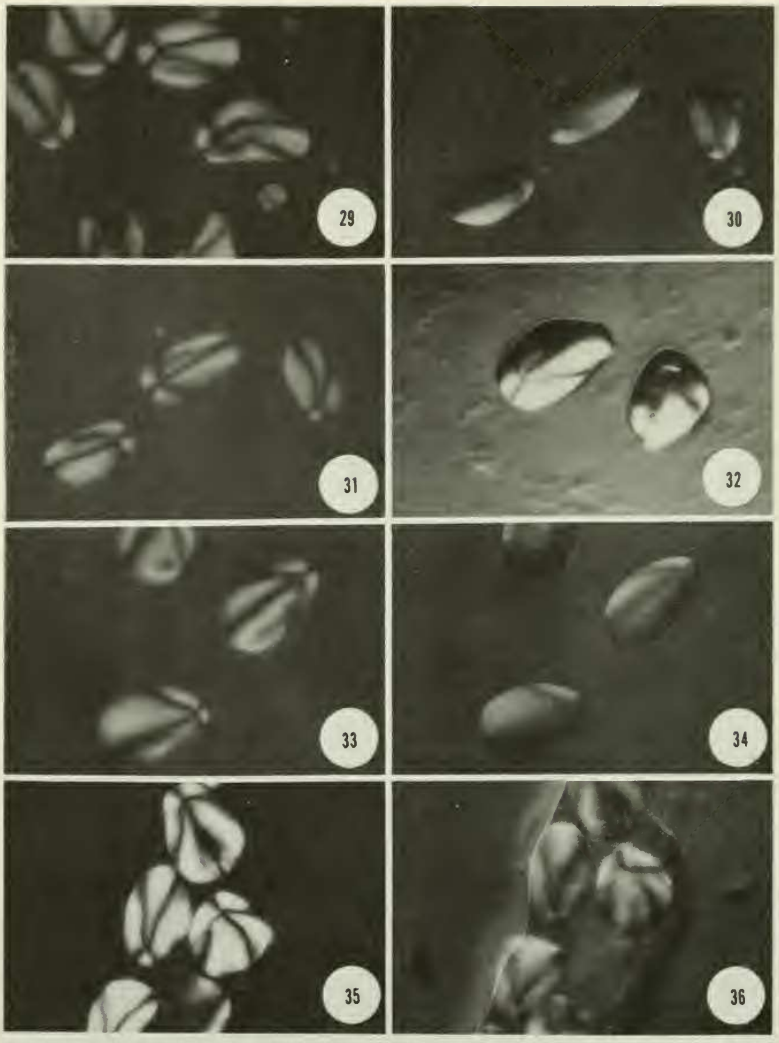
Figs. 5-12. Solanum starch (250x) photographed with polarized light (light field, left column; dark field, right column): 5-6. S. stoloniferum; 7-8. S. jamesii; 9-10. S. trifidum; and 11-12. S. polyadenium.



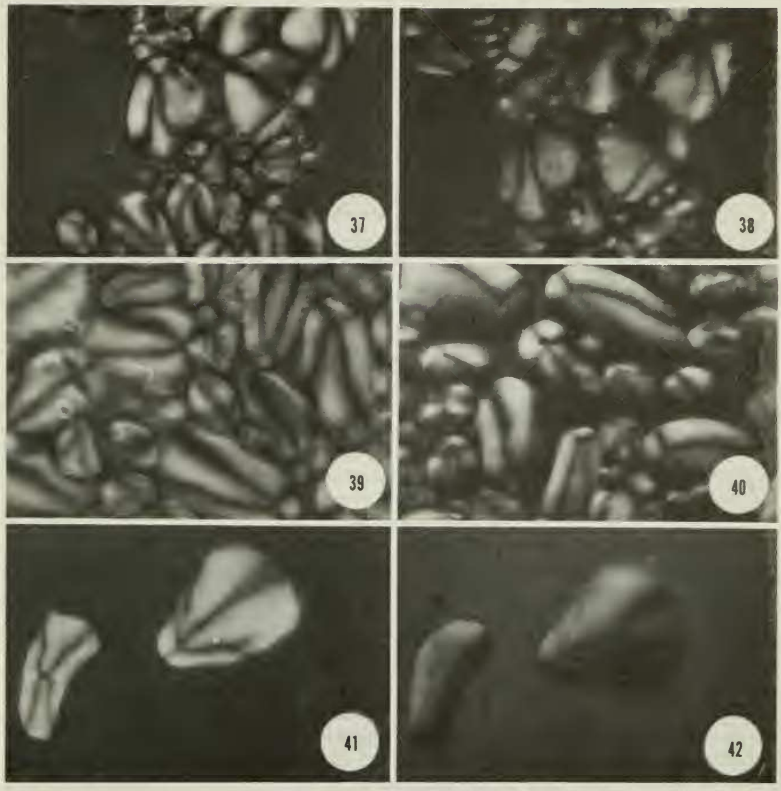
Figs. 13-20. Solanum starch (250x) photographed with polarized light (light field, left column; dark field, right column): 13-14. S. brachistotrichum; 15-16. S. bulbocastanum; 17-18. S. polytrichon; 19-20. S. cardiophyllum.



Figs. 21-28. Solanum starch (250x) photographed with polarized light (light field, left column; dark field, right column): 21-22. S. fendleri 23-24. S. demissum; 25-26. S. papita and 27-28. S. morelliforme.



Figs. 29-36. Solanum starch (250x) photographed with polarized light (light field, left column; dark field, right column): 29-30. S. verrucosum; 31-32. S. stenophyllidum; 33-34. S. clarum and 35-36. S. brachycarpum.



Figs. 37-42. Solanum starch (250x) photographed with polarized light (light field, left column; dark field, right column): 37-38. S. tuberosum; 39-40. S. pinnatisectum; and 41-42. S. guerreroensa.